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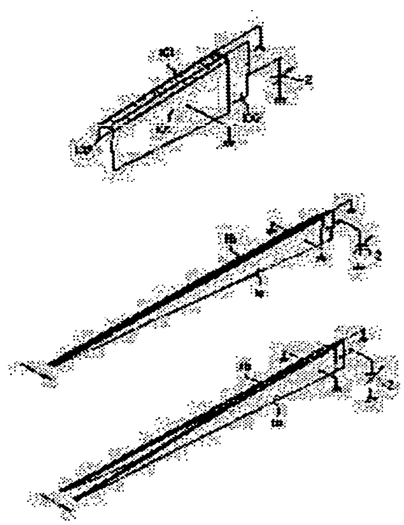
(54) SUPPORT MECHANISM, SUPPORT SYSTEM, ASSEMBLY METHOD AND ASSEMBLY DEVICE USING THEREOF

(57)Abstract:
PURPOSE: To softly hold a small part in vacuum by taking at least one part of two superposed plate like bodies as a bimorph type piezoelectric element.
CONSTITUTION: A pair of the bimorph type piezoelectric elements 1a, 1b worked in a wedge type are superposed to form a pincette mechanism. Namely, a set of wedge type figures are cut off lineally symmetrically from a sheet of the piezoelectric element plate, superposed so that the curving direction to the polarity of an impressing voltage becomes conflicting and the opening and closing motion of the pincette tip is enabled. In the case of the power pinching a sample being short, the output voltage polarity of a power source 2 is changed to curve the piezoelectric elements 1a, 1b to the inside and the pinching power is increased. In the case of gripping a larger sample and optimizing the contact state of the pincette and sample, a spacer may be inserted between two sheets composing the pincette.



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⑤発明の名称　支持機構、支持システム、それを用いた組立方法及び組立装置

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明　細　書

1. 発明の名称

支持機構、支持システム、それを用いた組立方法及び組立装置

2. 特許請求の範囲

1. 2枚重ね合わされた板状体の少なくとも一方がバイモルフ型圧電素子であることを特徴とする支持機構。

2. 2枚重ね合わされたバイモルフ型圧電素子よりなり、該バイモルフ型圧電素子は、それぞれに電圧が印加された際に互いに逆方向にわん曲する向きに配置されたことを特徴とする支持機構。

3. 請求項1又は2記載の支持機構、該支持機構を移動させるための移動手段及び該支持機構と該移動手段をそれぞれ制御するための制御手段よりなることを特徴とする支持システム。

4. 上記移動手段は、バイモルフ型圧電素子を連結した多軸マニピュレーターである請求項3記載の支持システム。

5. 請求項1又は2記載の支持機構、該支持機構を微動させるための微動手段、該微動手段を移動させるための粗動手段並びに該支持機構、該微動手段及び該粗動手段をそれぞれ制御するための制御手段よりなることを特徴とする支持システム。

6. 上記微動手段は、積層型圧電素子を連結した多軸マニピュレーターである請求項5記載の支持システム。

7. 試料台と、集束した荷電粒子ビームを試料台上の試料に照射するための集束荷電粒子ビーム光学系と、試料から発生する二次荷電粒子を検出するための検出器と、試料を保持するための請求項1又は2に記載の支持機構と、該支持機構を移動させるための移動手段とを内部に配置した真空装置、該支持機構と該移動手段とを制御するための制御手段及び該集束荷電粒子ビーム光学系を制御する偏向制御装置を有することを特徴とする組立装置。

8．請求項1又は2に記載の支持機構に試料を保持し、該支持機構を移動し、該支持機構の側壁電極を所望の電位とし、集束した荷電粒子ビームを上記試料に照射し、該試料から発生する二次荷電粒子を検出して該試料の状態を検出して該試料を組み立てることを特徴とする組立方法。

9．2枚の側壁電極と少なくとも1枚の中間電極を有するバイモルフ型圧電素子において、該側壁電極を該中間電極より大きくしたことを特徴とするバイモルフ型圧電素子。

10．上記側壁電極に一定の電圧を印加する手段を接続し、上記中間電極に変化する電圧を印加する手段を接続した請求項9記載のバイモルフ型圧電素子。

11．請求項9又は10記載のバイモルフ型圧電素子を請求項1又は2記載のバイモルフ型圧電素子として用いたことを特徴とする支持機構。

12．請求項9又は10記載のバイモルフ型圧電素子を請求項4記載のバイモルフ型圧電素子として用いたことを特徴とする支持システム。

13．2枚の板状部材よりなる支持機構を用いて試料を保持し、該支持機構を介して該試料を外部回路と電気的に接続して該試料に所望の動作させながら該試料を移動させることを特徴とする運搬方法。

14．上記支持機構として、請求項1又は2記載の支持機構を用いることを特徴とする請求項13記載の運搬方法。

15．上記試料として光－電気又は電気－光変換素子を用い、基板上に形成された導波路端部の所望の位置に移動させることを特徴とする請求項13又は14記載の運搬方法。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は、微細な物品等を支持するのに好適な支持機構、支持システム、それを用いた組立方法及び組立装置並びにバイモルフ型圧電素子及び運搬方法に関する。

〔従来の技術〕

従来、微細な物品、例えば半導体ペレット等を支持する支持機構は、特公昭56－52448に記載されているように、真空吸着するための開孔を備えた支持具を有し、これに半導体ペレット等を真空吸着していた。この支持機構により、微細な物品を損傷を与えることなく支持することが可能であった。

〔発明が解決しようとする課題〕

上記の従来技術は、大気中での使用を前提としたものであり、真空チャンバー内での使用は原理的に不可能であるという問題があった。

またバイモルフ型圧電素子は、内部の電極より電界がしみ出すという問題があった。

また微細試料を移動させるときは、高精度で所望の位置に合わせることが困難であるという問題があった。

本発明の第1の目的は、真空チャンバー内でも微細部品を保持できる支持機構及び支持システム並びにこれを用いた組立方法及び組立装置を提供することにある。

本発明の第2の目的は、内部の電極より発生する電界のしみだしを防止したバイモルフ型圧電素子を提供することにある。

本発明の第3の目的は、微細試料を所望の位置に高精度で移動できる運搬方法を提供することにある。

〔課題を解決するための手段〕

上記第1の目的は、下記1～8、10、11、12、14、15項によって、上記第2の目的は、下記9～12項によって、上記第3の目的は、下記13～15項によってそれぞれ達成される。

（1）2枚重ね合わされた板状体の少なくとも一方がバイモルフ型圧電素子であることを特徴とする支持機構。

（2）2枚重ね合わされたバイモルフ型圧電素子よりなり、該バイモルフ型圧電素子は、それぞれに電圧が印加された際に互いに逆方向にわん曲する向きに配置されたことを特徴とする支持機構。

（3）上記1又は2記載の支持機構、該支持機構を移動させるための移動手段及び該支持機構と該移動手段をそれぞれ制御するための制御手段より

なることを特徴とする支持システム。

(4) 上記移動手段は、バイモルフ型圧電素子を連結した多軸マニピュレーターである上記3記載の支持システム。

(5) 上記1又は2記載の支持機構、該支持機構を微動させるための微動手段、該微動手段を移動させるための粗動手段並びに該支持機構、該微動手段及び該粗動手段をそれぞれ制御するための制御手段よりなることを特徴とする支持システム。

(6) 上記微動手段は、積層型圧電素子を連結した多軸マニピュレーターである上記5記載の支持システム。

(7) 試料台と、集束した荷電粒子ビームを試料台上の試料に照射するための集束荷電粒子ビーム光学系と、試料から発生する二次荷電粒子を検出するための検出器と、試料を保持するための上記1又は2に記載の支持機構と、該支持機構を移動させるための移動手段とを内部に配置した真空装置、該支持機構と該移動手段とを制御するための制御手段及び該集束荷電粒子ビーム光学系を制御する偏向制御装置を有することを特徴とする組立装置。

(8) 上記1又は2に記載の支持機構に試料を保持し、該支持機構を移動し、該支持機構の側壁電極を所望の電位とし、集束した荷電粒子ビームを上記試料に照射し、該試料から発生する二次荷電粒子を検出して該試料の状態を検出して該試料を組み立てることを特徴とする組立方法。

(9) 2枚の側壁電極と少なくとも1枚の中間電極を有するバイモルフ型圧電素子において、該側壁電極を該中間電極より大きくしたことを特徴とするバイモルフ型圧電素子。

(10) 上記側壁電極に一定の電圧を印加する手段を接続し、上記中間電極に変化する電圧を印加する手段を接続した上記9記載のバイモルフ型圧電素子。

(11) 上記9又は10記載のバイモルフ型圧電素子を上記1又は2記載のバイモルフ型圧電素子として用いたことを特徴とする支持機構。

(12) 上記9又は10記載のバイモルフ型圧電素子を上記4記載のバイモルフ型圧電素子として用いたことを特徴とする支持システム。

(13) 2枚の板状部材よりなる支持機構を用いて試料を保持し、該支持機構を介して該試料を外部回路と電気的に接続して該試料に所望の動作させながら該試料を移動させることを特徴とする運搬方法。

(14) 上記支持機構として、上記1又は2記載の支持機構を用いることを特徴とする上記13記載の運搬方法。

(15) 上記試料として光ー電気又は電気ー光変換素子を用い、基板上に形成された導波路端部の所望の位置に移動させることを特徴とする上記13又は14記載の運搬方法。

【作　用】

バイモルフ型圧電素子は、電圧を印加することにより撓み運動をする。それ故、二枚の板状体の少なくとも一方をバイモルフ型圧電素子とし、両者を重ね合わせ、該素子に電圧を印加すれば一端が近接、離隔し、開閉運動をする。よって支持機構として作用する。

【実施例】

以下、本発明の実施例を図を用いて説明する。

実施例 1

第1図は本発明の支持機構の一実施例であるピンセット機構を示す構成図である。ここで用たバイモルフ型圧電素子は、第1図(a)に示すように、3枚の電極板の間に2枚の圧電材料102(ジルコン酸チタン酸塩)を挟み込んだもので、中間電極100と外側の側壁電極101との間に電源2から電圧を印加すると圧電素子はわん曲する。第1図(b)及び(c)に示すように、くさび型に加工した一対のバイモルフ型圧電素子1a、1bを重ね合わせ、ピンセット機構を形成した。すなわち、圧電素子板一枚から、くさび型図形を線対象に一組切り抜き、印加電圧の極性に対するわん曲方向が相反するように重ね合わせ、ピンセット先端の開閉運動を可能とした。第1図(b)は電源2の出力電圧を0Vとし、ピンセットが閉じた状態を示したものである。この場合、圧電素

子の弾性力により、ピンセットは閉じている。試料を挟む力が不足する場合は、電源2の出力電圧極性を変えて、圧電素子を内側にわん曲させ、挟む力を増大させる。第1図(c)は中間電極に+30Vの電圧を印加し、ピンセットを開いた様子を示したものである。ピンセット長30㎜で500μmの開口距離が得られた。より大きな試料を掴みたい場合やピンセットと試料との接触状態を最適化したい場合は、ピンセットを構成する2枚の板の間にスペーサを挿入すれば良い。本実施例のピンセット機構は構成がシンプルで軽量小型であり、特に真空中で微細部品をソフトに掴む用途に好適である。

実施例 2

第2図に、ピンセット機構をバイモルフ型圧電素子を連結した3軸マニピュレーター先端に装着し、試料の3次元移動を可能とした支持システムを示す。バイモルフ型圧電素子1c、1d、1eを90度ずつ曲げて接続し、x、y、zの3軸の駆動を可能とし、先端に実施例1で示したピンセット機構を装着した。圧電素子寸法は10㎜×30㎜、厚みは0.5㎜である。中間電極と側壁電極との間に±30V印加すると約±500μmの変位が得られる。本実施例では、各圧電素子1c、1d、1eに3個の電源(図示せず)を直接接続した。バイモルフ型圧電素子はたわみ運動するため、各素子の先端部は一軸の変位とはならない。つまり、圧電素子1cに印加する出力電圧を変えることで、ピンセット機構先端はx軸とy軸の2軸変化する。このような構成でも、試料を顕微鏡等で観察しながら電源を操作することにより、マニピュレーターとして十分実用になる。各軸単独に操作したい場合は、直交座標系の移動データー信号から各圧電素子の駆動電圧を発生する補正回路を用いればよい。この補正回路を実現する手法として、演算によるものと対応表によるものとがある。

本実施例の支持システムは、バイモルフ型圧電素子を利用しているため、小型軽量にもかかわらず移動距離が大きく、例えば、半導体チップ等の軽量部品をソフトに運搬する用途に適している。

実施例 3

第3図は、積層型圧電素子ブロック3を変位の方向を各90度傾けて3個積み重ねて構成した3軸マニピュレーターに、実施例1に示したピンセット機構を搭載した支持システムの例である。積層型圧電素子は移動距離が小さい欠点を有するが、ドリフトやヒステリシスが小さく、位置精度が高く振動にも強いため、高精度の位置決めが要求される用途に好適である。

実施例 4

実用的な駆動距離を確保するために、第3図に示した3軸マニピュレーターを別の広範囲に移動できるマニピュレーターにさらに連結して装置構成した例を示す。本実施例の支持システムは、第4図に示すように、実施例1に示したピンセット機構20を、実施例3に示した積層型圧電ブロックを連結した3軸マニピュレーターよりなる微動手段21に搭載し、この微動手段21をさらにステッピングモーターとウォームギヤを用いた粗動手段22に連結し、これらを制御する制御手段23を設けたものである。積層型圧電ブロックを用いた3軸マニピュレーターは高精度の位置決めが可能であるが、変位量が10~100μmと小さいので本実施例のように粗動手段と組み合わせて用いることが好ましい。また微動手段21として変位量が大きいものを用いれば粗動手段はなくてもよい。

実施例 5

第5図に、実施例1に示したピンセット機構を有する組立て装置を示す。この組立て装置は、真空装置(図示せず)内に、試料台40、集束した荷電粒子ビームを試料台上の試料41に照射するための集束イオンビーム光学系30、試料41から発生する二次荷電粒子を検出する2次荷電粒子検出器33、試料を保持し、移動させるためのピンセット機構20、ピンセット機構20を移動させる微動手段21及びガスを導入するノズル9を配置し、さらにピンセット機構20と微動手段21を制御する制御手段23、試料からビーム誘

引に同期して発生した二次荷電粒子を検出して画像でモニターするための画像表示装置（ＣＲＴ）３２及び集束イオンビーム光学系を制御する偏向制御装置３１を設けてある。また、上記ピンセット機構を介して試料に電圧を印加するための電源（図示せず）が設けられている。なお、本実施例において、微動手段２１として、実施例２に記載のバイモルフ型圧電素子を連結した３軸マニピュレーターを用いた。

次にこの装置を用いて半導体レーザーを実装した例を示す。第６図は、実装する試料近傍の斜視図である。半導体レーザーチップ５を導波路６端面に実装する場合、良好な結合効率を得るためには正確な位置合わせが必要である。これを行なうには、（１）半導体レーザーを実際に発光させ、導波路に入射した光の強度を測定しながら位置合わせを行なう方法と、（２）導波路の出力端から逆に光を入射し、半導体レーザーを光センサーとして動作させて、光強度を測定しながら位置合わせを行なう方法がある。本実施例は前者の方法を用いたもので、ピンセット機構２０を介して半導体レーザーチップ５に電源１１を接続し、位置合わせを行なった。半導体レーザーチップ５の固定及び配線はＷ（ＣＯ）。金属ガス１０雰囲気中での集束イオンビーム（ＦＩＢ）４照射によるＷ堆積膜７により電源ライン８に接続することで行なった。ガスはノズル９により加工部に局所照射した。本実施例のように、ピンセット機構を介して、試料と外部回路との電気的接続を行なうと、試料を動作させながら運搬することが可能となる。

本実施例のように、ＦＩＢを利用して試料の固定や配線を行なう場合、デバイスの状況を、ＦＩＢ掃引に同期して検出した二次荷電粒子（二次電子、二次イオン）による画像でモニターする。二次荷電粒子は低エネルギー粒子であり、それらの運動軌道は１次ビーム照射部近傍の電界及び磁界に影響されやすい。従って、ピンセット機構の電位は、二次電子を検出する場合０Ｖ以下の負電位に、正の二次イオンを検出する場合０Ｖ以上の正電位にする必要があり、これにより荷電粒子が捕獲されず、検出感度の低下を防ぐことができる。試料に異なる電位を供給する必要のない場合や、ピンセット先端部でコンタクト点を有する配線を這わせ、試料に電源供給等を行なう場合は、圧電素子側壁を接地電位とすることで、１次ビーム及び２次ビームへの影響を無くすことができる。バイモルフ型圧電素子は積層構造の見える端面に中間電極が露出する。これにより、局部に電界がしみだし、これがビーム照射部近傍にある場合、二次電子等に影響を与える。従って、中間電極を側壁電極より小さくする等により、側壁電極で中間電極により発生する電界をシールドすることが望ましい。

【発明の効果】

本発明によれば、真空中で微細部品をソフトに保持することができる。また、試料を電気的動作させながら運搬することもできる。

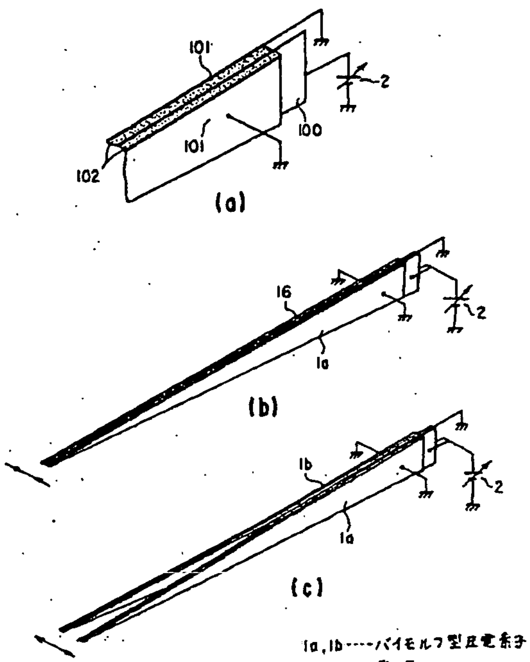
４．図面の簡単な説明

第１図は本発明の支持機構の基本構成を示す一実施例の構成図、第２図、第３図は３軸マニピュレーターと支持機構とを組み合わせた一実施例の構成図、第４図は本発明の支持システムの一実施例の構成図、第５図は本発明の組立装置の一実施例の構成図、第６図はその試料近傍の斜視図である。

１ａ、１ｂ、１ｃ、１ｄ、１ｅ…バイモルフ型圧電素子
２…電源
３…積層型圧電素子ブロック
４…集束イオンビーム
５…半導体レーザーチップ
６…導波路　　　　７…堆積膜
８…電源ライン　　９…ノズル
１０…ガス　　　　１１…電源
２０…ピンセット機構　２１…微動手段
２２…粗動手段　　２３…制御手段
３０…集束イオンビーム光学系
３１…偏向制御装置　３２…画像表示装置
３３…２次荷電粒子検出器
４０…試料台　　　４１…試料

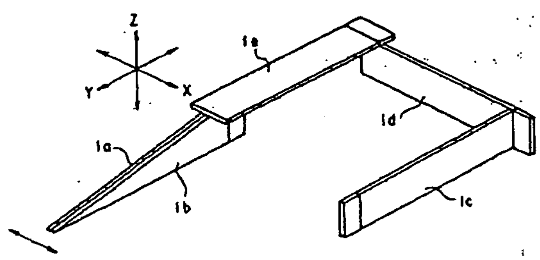
１００…中間電極　　　１０１…側壁電極
１０２…圧電材料

代理人弁理士　　中村　純之助

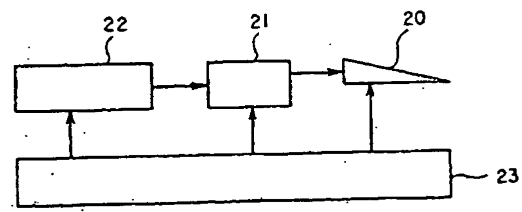


1a, 1b----バイモルフ型圧電素子
2----電源

第 1 図

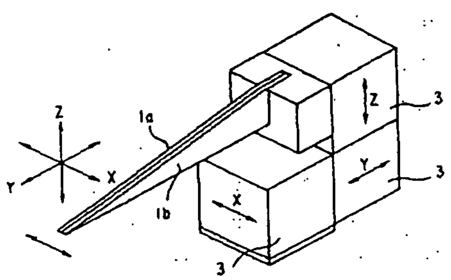


第 2 図



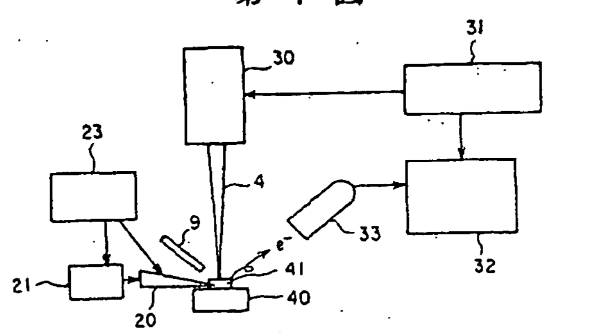
20-----ピンセット機構　　22-----粗動手段
21-----微動手段　　23-----制御手段

第 4 図



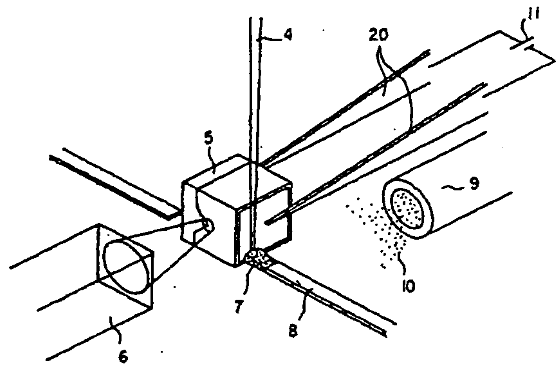
3-----積層型圧電素子ブロック

第 3 図



30----集束イオンビーム光学系　　33----2次荷電粒子検出器
31----偏向制御装置　　40----試料台
32----画像表示装置　　41----試料

第 5 図



4----集束イオンビーム
5----半導体レーザチップ
6----導波路
7----堆積膜
8----電源ライン
9----ノズル
10----ガス
11----電源

第6図

PTO 03-3025

Japanese Kokai Patent Application
No. Hei 3[1991]-154784

SUPPORTING MECHANISM, SUPPORTING SYSTEM, ASSEMBLY METHOD AND ASSEMBLY DEVICE USING SAME

Takeshi Onishi, et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
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SUPPORTING MECHANISM, SUPPORTING SYSTEM, ASSEMBLY METHOD AND ASSEMBLY DEVICE USING SAME

[Shiji kiko, shiji shisutemu, sore o mochiita kumitate hoho oyobi kumitate sochi]

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Applicant:	Hitachi, Ltd.

There are no amendments to this patent.

Claims /1*

1. A supporting mechanism characterized by the fact that at least one of two overlapped plate-shape bodies is a bimorphic piezoelectric element.

2. A supporting mechanism characterized by the following facts: it comprises two overlapped bimorphic piezoelectric elements; the bimorphic piezoelectric elements are arranged in appropriate directions such that they are bent in opposite directions when voltages are applied to them.

* Numbers in the margin indicate pagination in the foreign text.

3. A supporting system characterized by the fact that it is composed of the supporting mechanism described in Claim 1 or 2, a moving means that moves said supporting mechanism, and a control means for controlling said supporting mechanism and said moving means.

4. The supporting system described in Claim 3 characterized by the fact that said moving means is a multi-axis manipulator connected to the bimorphic piezoelectric elements.

5. A supporting system characterized by the fact that it is composed of the supporting mechanism described in Claim 1 or 2, a fine moving means for fine movement of said supporting mechanism, a rough moving means that moves said fine moving means, and a control means for controlling said fine moving means and said rough moving means.

6. The supporting system described in Claim 5 characterized by the fact that said fine moving means is a multi-axis manipulator connected to the overlapped piezoelectric elements.

7. An assembly device characterized by the fact that it has the following parts: a vacuum device, which contains the following parts inside it: a sample table, a focused charge particle beam optical system for irradiating a sample on a sample table, a detector for detecting the secondary charge particles generated from the sample on the sample table, a supporting mechanism described in Claim 1 or 2 for holding the sample, and a moving means for moving said supporting mechanism; a control means for controlling said supporting mechanism and said moving means; and a deflecting controller that controls said focused charge particle beam optical system. /2

8. An assembly method characterized by the following facts: a sample is held in the supporting mechanism described in Claim 1 or 2; the supporting mechanism is driven to move; the side wall electrode of the supporting mechanism is set at a prescribed potential; a focused charge particle beam is irradiated on said sample; the secondary charge particles generated from the sample are detected to detect the state of the sample.

9. A bimorphic piezoelectric element characterized by the fact that the bimorphic piezoelectric element has two side wall electrodes and at least one middle electrode, and said side wall electrodes are larger than said middle electrode.

10. The bimorphic piezoelectric element described in Claim 9 characterized by the fact that a means for applying a fixed voltage is connected to said side wall electrodes, and a means for applying a varying voltage is connected to said middle electrode.

11. A supporting mechanism characterized by the fact that the bimorphic piezoelectric element described in Claim 9 or 10 is used as the bimorphic piezoelectric element described in Claim 1 or 2.

12. A supporting system characterized by the fact that the bimorphic piezoelectric element described in Claim 9 or 10 is used as the bimorphic piezoelectric element described in Claim 4.

13. A transporting method characterized by the fact that a supporting mechanism made of two plate-shaped members is used to hold a sample, and, through the supporting mechanism, said sample is electrically connected to the outer circuit so that the prescribed operation is performed for said sample while the sample is driven to move.

14. The transporting method described in Claim 13 characterized by the fact that the supporting mechanism described in Claim 1 or 2 is used as the aforementioned supporting mechanism.

15. The transporting method described in Claim 13 or 14 characterized by the fact that an optoelectrical or electrooptical converting element is used as said sample, and it is driven to move to the prescribed position at the end portion of a waveguide path formed on a substrate.

Detailed explanation of the invention

Application field in industry

This invention pertains to a supporting mechanism that can be used preferably in supporting thin object or the like, a supporting system, an assembly method and an assembly device using said system, as well as a bimorphic piezoelectric element and a transporting method.

Prior art

As described in Japanese Kokoku Patent Application No. Sho 56[1981]-52448, the conventional supporting mechanism for supporting a thin object, such as semiconductor pellet or the like, has a supporting tool that has a hole for vacuum application, with semiconductor pellet or the like vacuum adhered to it. By means of this supporting mechanism, it is possible to support thin objects without damaging them.

Problems to be solved by the invention

In the aforementioned prior art, the precondition is that it is for use in atmosphere. In principle, it cannot be used in a vacuum chamber. This is a problem.

Also, for bimorphic piezoelectric elements, electric field leaks out from the internal electrode. This is undesired.

In addition, when a thin sample is driven to move, it is hard to fit at a prescribed position at a high precision. This is a problem.

The first purpose of this invention is to provide a supporting mechanism and supporting system for holding a thin member even in a vacuum chamber, as well as an assembly method and assembly device using said supporting mechanism and supporting system.

The second purpose of this invention is to provide a bimorphic piezoelectric element free of leakage of electric field from the internal electrode.

The third purpose of this invention is to provide a transporting method that can drive to move a delicate sample to a prescribed position at a high precision.

Means for solving the problem

Said first purpose is realized by means of below-listed items 1-8, 10, 11, 12, 14 and 15. Said second purpose is realized by means of below-listed items 9-12. Said third purpose is realized by means of below-listed items 13-15.

(1) A supporting mechanism characterized by the fact that at least one of two overlapped plate-shape bodies is a bimorphic piezoelectric element.

(2) A supporting mechanism characterized by the following facts: it is made of two overlapped bimorphic piezoelectric elements; the bimorphic piezoelectric elements are arranged in appropriate directions such that they are bent in opposite directions when voltages are applied to them.

(3) A supporting system characterized by the fact that it is composed of the supporting mechanism described in (1) or (2), a moving means that moves said supporting mechanism, and a control means for controlling said supporting mechanism and said moving means. /3

(4) The supporting system described in (3) characterized by the fact that said moving means is a multi-axis manipulator connected to the bimorphic piezoelectric elements.

(5) A supporting system characterized by the fact that it is composed of the supporting mechanism described in (1) or (2), a fine moving means for fine movement of said supporting mechanism, a rough moving means that moves said fine moving means, and a control means for controlling said fine moving means and said rough moving means.

(6) The supporting system described in (5) characterized by the fact that said fine moving means is a multi-axis manipulator connected to the overlapped piezoelectric elements.

(7) An assembly device characterized by the fact that it has the following parts: a vacuum device, which contains the following parts inside it: a sample table, a focused charge particle beam optical system for irradiating a sample on a sample table, a detector for detecting the secondary charge particles generated from the sample on the sample table, a supporting mechanism described in Claim 1 or 2 for holding the sample, and a moving means for moving said supporting mechanism; a control means for controlling said supporting mechanism and said moving means; and a deflecting controller that controls said focused charge particle beam optical system.

(8) An assembly method characterized by the following facts: a sample is held in the supporting mechanism described in (1) or (2); the supporting mechanism is driven to move; the

side wall electrode of the supporting mechanism is set at a prescribed potential; a focused charge particle beam is irradiated on said sample; the secondary charge particles generated from the sample are detected to detect the state of the sample.

(9) A type of bimorphic piezoelectric element characterized by the fact that the bimorphic piezoelectric element has two side wall electrodes and at least one middle electrode, and said side wall electrodes are larger than said middle electrode.

(10) The bimorphic piezoelectric element described in (9) characterized by the fact that a means for applying a fixed voltage is connected to said side wall electrodes, and a means for applying a varying voltage is connected to said middle electrode.

(11) A supporting mechanism characterized by the fact that the bimorphic piezoelectric element described in (9) or (10) is used as the bimorphic piezoelectric element described in (1) or (2).

(12) A type of supporting system characterized by the fact that the bimorphic piezoelectric element described in (9) or (10) is used as the bimorphic piezoelectric element described in (4).

(13) A transporting method characterized by the fact that a supporting mechanism made of two plate-shaped members is used to hold a sample, and, through the supporting mechanism, said sample is electrically connected to the outer circuit so that the prescribed operation is performed for said sample while the sample is driven to move.

(14) The transporting method described in (13) characterized by the fact that the supporting mechanism described in (1) or (2) is used as the aforementioned supporting mechanism.

(15) The transporting method described in (13) or (14) characterized by the fact that a optoelectrical or electrooptical converting element is used as said sample, and it is driven to move to the prescribed position at the end portion of a waveguide path formed on a substrate.

Operation

When a voltage is applied to a bimorphic piezoelectric element, bending movement takes place. As a result, when two plate-shape bodies with at least one of them made of a bimorphic piezoelectric element are overlapped, the two bodies move towards each other or away from each other when a voltage is applied to the element, that is, an opening/closing operation is performed. Consequently, the system functions as a supporting mechanism.

Application Examples

In the following, application examples of this invention will be explained with reference to figures.

Application Example 1

Figure 1 is a diagram illustrating the constitution of the pincette mechanism as an application example of the supporting mechanism of this invention. As shown in Figure 1(a), the bimorphic piezoelectric element used in this case has two piezoelectric material sheets (102) (zirconate titanate salt) sandwiched between three electrode plates. When a voltage is applied from power source (2) between middle electrode (100) and outer side wall electrode (101), the piezoelectric element bends. As shown in Figures 1(b) and (c), a pair of bimorphic piezoelectric elements (1a), (1b) processed into a wedge shape are overlapped to form a pincette mechanism. That is, from a single piezoelectric element plate, a group of wedge-shaped plates are cut out, and they are overlapped with their bending directions under an applied voltage opposite to each other with respect to the sign of the applied voltage. As a result, the tip portion of the pincette can undergo an opening/closing movement. Figure 1(b) illustrates the case when the output voltage of power source (2) is 0 V, and the pincette is in the closed state. In this case, due to the /4
elastic force of the piezoelectric elements, the pincette is closed. When the force in holding the sample is insufficient, one can change the sign of the output voltage of power source (2) to have the piezoelectric elements bend inward so as to increase the holding force. Figure 1(c) illustrates the state when a voltage of +30 V is applied on the middle electrode, so that the pincette is opened. For a pincette with length of 30 mm, an opening distance of 500 μm can be realized. When a larger sample is to be held, or when the contact state between the pincette and the sample is to be optimized, one may insert a spacer between the two sheets that form the pincette. For the pincette mechanism in this application example, the constitution is simple, lightweight and small in size, and it is especially preferred for use in softly holding thin members in vacuum.

Application Example 2

Figure 2 is a diagram illustrating a supporting system that is installed on the tip of a 3-axis manipulator with a pincette mechanism connected to a bimorphic piezoelectric element, and allows 3-dimensional movement of a sample. Bimorphic piezoelectric elements (1c), (1d), and (1e) are connected to each other at 90° in each connecting point. It allows driving in the three axes x, y and z. The pincette mechanism in Application Example 1 is installed at the tip, with piezoelectric elements in dimensions of 10 mm x 30 mm and 0.5 mm in thickness. When a voltage of ±30 V is applied between the middle electrode and the side wall electrode, a displacement of about ±500 μm can be obtained. In this application example, three power sources (not shown in the figure) are directly connected to said piezoelectric elements (1c), (1d), (1e). When the bimorphic piezoelectric elements deflect, displacement at the tip portion of each element is not a single-axis displacement. That is, by changing the output voltage applied to

piezoelectric element (1c), the tip of the pincette mechanism undergoes a 2-axial variation in x-axis and y-axis. In this constitution, too, by manipulating the power source while observing the sample on a microscope or the like, one can use it as a manipulator well in practice. When manipulation is to be performed for each axis alone, one may make use of a correcting circuit that generates a driving voltage for each piezoelectric element from the movement data signal for an orthogonal coordinate system. As a means for realizing the correcting circuit, one may make use of a table corresponding to the results obtained in a computing operation.

The supporting system in this application example makes use of bimorphic piezoelectric elements. Consequently, it has a small size, a light weight, yet a large movement distance. For example, it can be used in softly carrying semiconductor chips or other lightweight members.

Application Example 3

Figure 3 is a diagram illustrating an example of a supporting system prepared by stacking three laminated piezoelectric element blocks (3) with displacement direction shifted by 90° with respect to each other to form a 3-axis manipulator, with the pincette mechanism in Application Example 1 carried on it. The laminated type piezoelectric elements have the disadvantage that the movement distance is small. However, drift and hysteresis are small, positioning precision is high, and the resistance to vibration is also high. Consequently, it is appropriate for use when there is a demand for high-precision positioning.

Application Example 4

In this example, the 3-axis manipulator is further connected to another manipulator that can move in a wide range to form a device to ensure the driving distance for practical use. As shown in Figure 4, the supporting system of this application example has pincette mechanism (20) in Application Example 1 carried on fine moving means (21) made of 3-axis manipulator formed by connecting the laminated type piezoelectric blocks shown in Application Example 3. This fine moving means (21) is further connected to a rough moving means (22) using a stepping motor and worm gears. Also, there is a control means (23) for controlling them. For the 3-axis manipulator prepared using laminated piezoelectric blocks, although positioning can be made at a high precision, the displacement is as small as 10-100 μm. Consequently, it is preferred that a rough moving means is used in combination as in this application example. Also, when fine moving means (21) with a large displacement is used, one may not make use of a rough moving means.

Application Example 5

Figure 5 is a diagram illustrating an assembly device having the pincette mechanism in Application Example 1. Said assembly device has the following parts in a vacuum device (not shown in the figure): sample table (40), focused ion beam optical system (30) for irradiating a focused charged particle beam onto sample (41) on the sample table, secondary charged particle detector (33) for detecting the secondary charged particles generated from sample (41), pincette mechanism (20) for holding and moving the sample, fine moving means (21) for moving pincette mechanism (20), and nozzle (9) for feeding a gas. In addition, it has control means (23) for controlling pincette mechanism (20) and fine moving means (21), image display unit (CRT) (32) for monitoring the image that detects the secondary charge particles generated from the sample in synchronization to beam scanning and deflection controller (31) for controlling the focused ion beam optical system. Also, there is a power source (not shown in the figure) for applying a voltage to the sample via said pincette mechanism. Also, in this application example, a 3-axis manipulator connected to the bimorphic piezoelectric element in Application Example 2 is in use as fine moving means (21).

The following is an example of the assembly of a semiconductor laser using the aforementioned device. Figure 6 is an oblique view illustrating the vicinity to the sample for assembly. When semiconductor laser (5) is assembled on the end surface of waveguide path (6), a correct positioning is necessary to realize a high coupling efficiency. The following methods may be adopted in this case: (1) a method in which the semiconductor laser is actually turned on to emit light, and, while the intensity of the light incident in the waveguide path is measured, position alignment is carried out; (2) a method in which light is incident from the output end of the waveguide path, and, with the semiconductor laser used as a light sensor, the light intensity is measured while position alignment is carried out. In this application example, the former method is adopted. In this case, power source (11) is connected through pincette mechanism (20) to semiconductor laser chip (5) for position alignment. Fixation and wiring of semiconductor laser chip (5) are carried out by connecting from W deposited film (7) to power source line (8) by means of irradiation of focused ion beam (FIB) (4) in an atmosphere of $W(CO)_{[illegible]}$ metal vapor (10). The vapor is locally irradiated on the processing portion by means of nozzle (9). In this application example, electrical connection between the sample and the external circuit is realized via the pincette mechanism, and it is possible to undertake transportation while the sample is in operation.

In this application example, when a FIB is used to perform fixation and wiring of the sample, the state of the device is monitored by means of the image of the secondary charge particles (secondary electrons, secondary ions) detected in synchronization to FIB sweeping. As the secondary charge particles are low-energy particles, their movement orbit is prone to

influence of the electric field and magnetic field near the primary beam irradiation portion. Consequently, the potential of the pincette mechanism should be a negative one below 0 V when secondary electrons are detected, and it should be a positive potential higher than 0 V when positive ions are detected. In this way, no charge particles are caught, and it is possible to prevent decrease in the detection sensitivity. When there is no need to feed a different potential to the sample, and when wire having a contact point is fed to reach the pincette tip portion so as to feed power to the sample, the side wall of the piezoelectric element is set to ground potential, and it is possible to eliminate the influence of the primary beam and secondary beam. For the bimorphic piezoelectric elements, the middle electrode is exposed on the end surface of the laminated structure. As a result, the electric field leaks to the periphery, and, when it is near the beam irradiation portion, it influences the secondary electrons, etc. Consequently, it is preferred that the electric field generated by the middle electrode be shielded with the side wall electrode by forming the middle electrode smaller than the side wall electrode.

Effects of the invention

According to this invention, it is possible to hold thin members in vacuum. Also, it is possible to transport the sample while electrical operations are carried out.

Brief description of figures

Figure 1 is a diagram illustrating the constitution of an application example showing the basic constitution of the supporting mechanism in this invention. Figures 2 and 3 illustrate the constitution of an application example in which a 3-axis manipulator and a supporting mechanism are combined. Figure 4 is a diagram illustrating the constitution of an application example of the supporting system in this invention. Figure 5 is a diagram illustrating the constitution of an application example of the assembly device in this invention. Figure 6 is an oblique view illustrating the vicinity to the sample.

1a, 1b, 1c, 1d, 1e	Bimorphic piezoelectric element
2	Power source
3	Laminated piezoelectric element block
4	Focused ion beam
5	Semiconductor laser chip
6	Waveguide path
7	Deposited film
8	Power source line
9	Nozzle

10	Gas
11	Power source
20	Pincette mechanism
21	Fine moving means
22	Rough moving means
23	Control means
30	Focused ion beam optical system
31	Deflection control device
32	Image display device
33	Secondary charge particle detector
40	Sample table
41	Sample
100	Middle electrode
101	Side wall electrode
102	Piezoelectric material

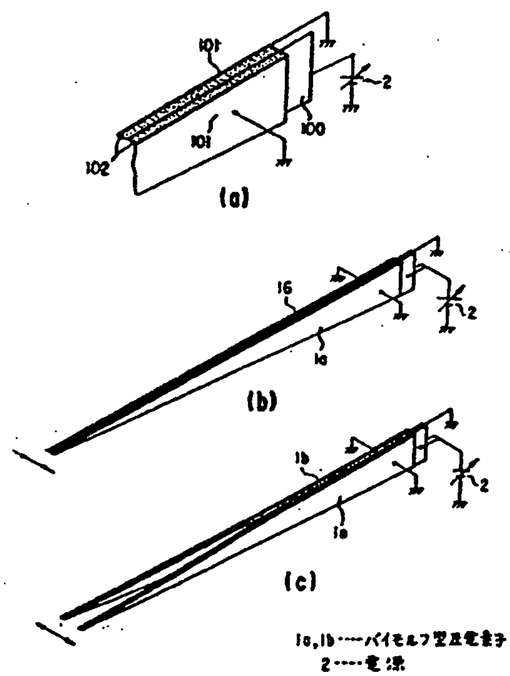


Figure 1

Key: 1a, 1b Bimorphic piezoelectric element
2 Power source

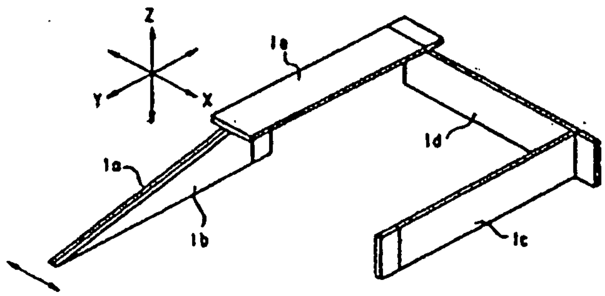
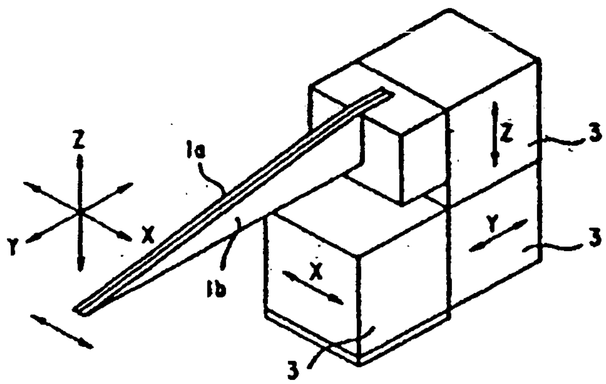


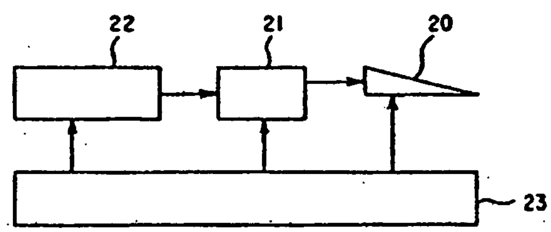
Figure 2



3……積層型圧電素子ブロック

Figure 3

Key: 3 Laminated type piezoelectric element block



20……ピンセット機構　22……粗動手段
21……微動手段　23……制御手段

Figure 4

Key:
- 20 Pincette mechanism
- 21 Fine moving means
- 22 Rough moving means
- 23 Control means

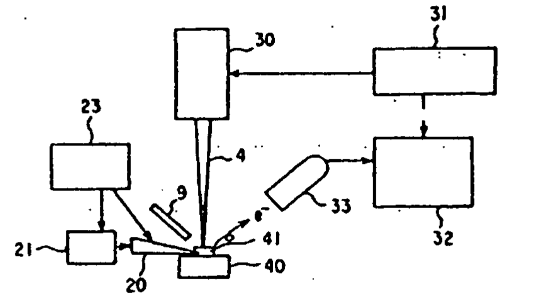


Figure 5

Key:
30 Focused ion beam optical system
31 Deflection control device
32 Image display device
33 Secondary charge particle detector
40 Sample table
41 Sample

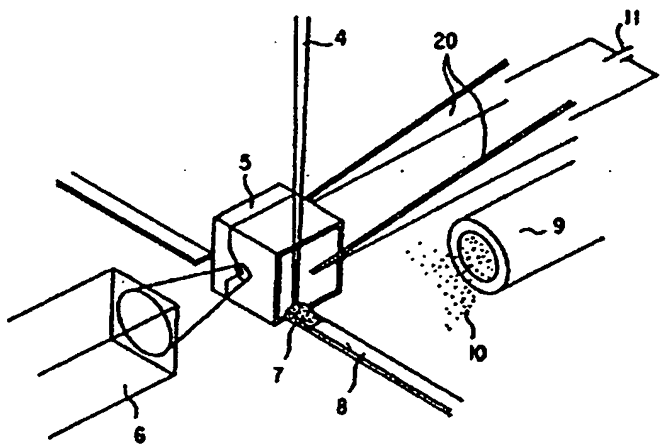


Figure 6

4 Focused ion beam
5 Semiconductor laser chip
6 Waveguide path
7 Deposited film
8 Power source line

9 Nozzle
10 Gas
11 Power source